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Systems Center
San Diego

Advancing Autonomy on Man Portable Robots

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Introduction

- Autonomous Robotic Mapping System (ARMS)
 - Hardware
 - Software: Refactored Robotic Intelligence Kernel (RRIK)
 - Capabilities (SLAM, Exploration, AEKF, Target Following)
- ONR's Center for Commercialization of Advanced Technologies (CCAT) Payloads
- Future Work
- Automatically Deployed Communications Relays



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ARMS Overview

- Goals:
 - Provide Reconnaissance of Targets of Interest Using Man-Portable System
 - Keep Operator Out of Harm's Way
 - Reduce Operator Workload
 - Increase Operator Situational Awareness
- Initial Capabilities:
 - Autonomously Map Selected Building/Area
 - Geo-Reference Map and Sensor Data
- Future Capabilities:
 - Report Anomalies (Moving Objects, Weapons, etc.)
 - Enhance Mission Capabilities (Manipulation, Explosives and Radiation Detection, etc.)



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ARMS Hardware

- Packbot Scout Chassis
- Navigator Payload
 - SICK LD-OEM
 - Ublox GPS
 - 3DM-GX1
 - KVH Gyro
 - Serial Radio
- SEER Payload
 - TYZX Stereo Vision





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ARMS Software: Refactored RIK

Sequence of
behaviors to
achieve high level
capabilities.

Produce actuator
command to achieve
given goal based on
perceptual and device
data.

Produce “more useful”
data by analyzing and
fusing data from
devices and other
perceptions.

Source data
and sink
commands.
Connection
to real world.

Tasks

Explore

Find Rad.
Source

Warfighter's
Associate

Behaviors

ODOA

Follow

Retro
Traverse

Waypoint

Visual
Targeting

Etc.

**Generic
Comms
(JAUS, INL,
SPAWAR,
etc.)**

Perceptions

SLAM

Obstacle
Map

Explore
Goals

Doorway

Path
Planning

Skin
Detection

AEKF

Etc.

Devices (Aware2, Player, etc.)

Position

LADAR

Stereo
Vision

IMU

GPS

Video

Rad.
Sensor

PTZ

Weapon

Soldier
Data

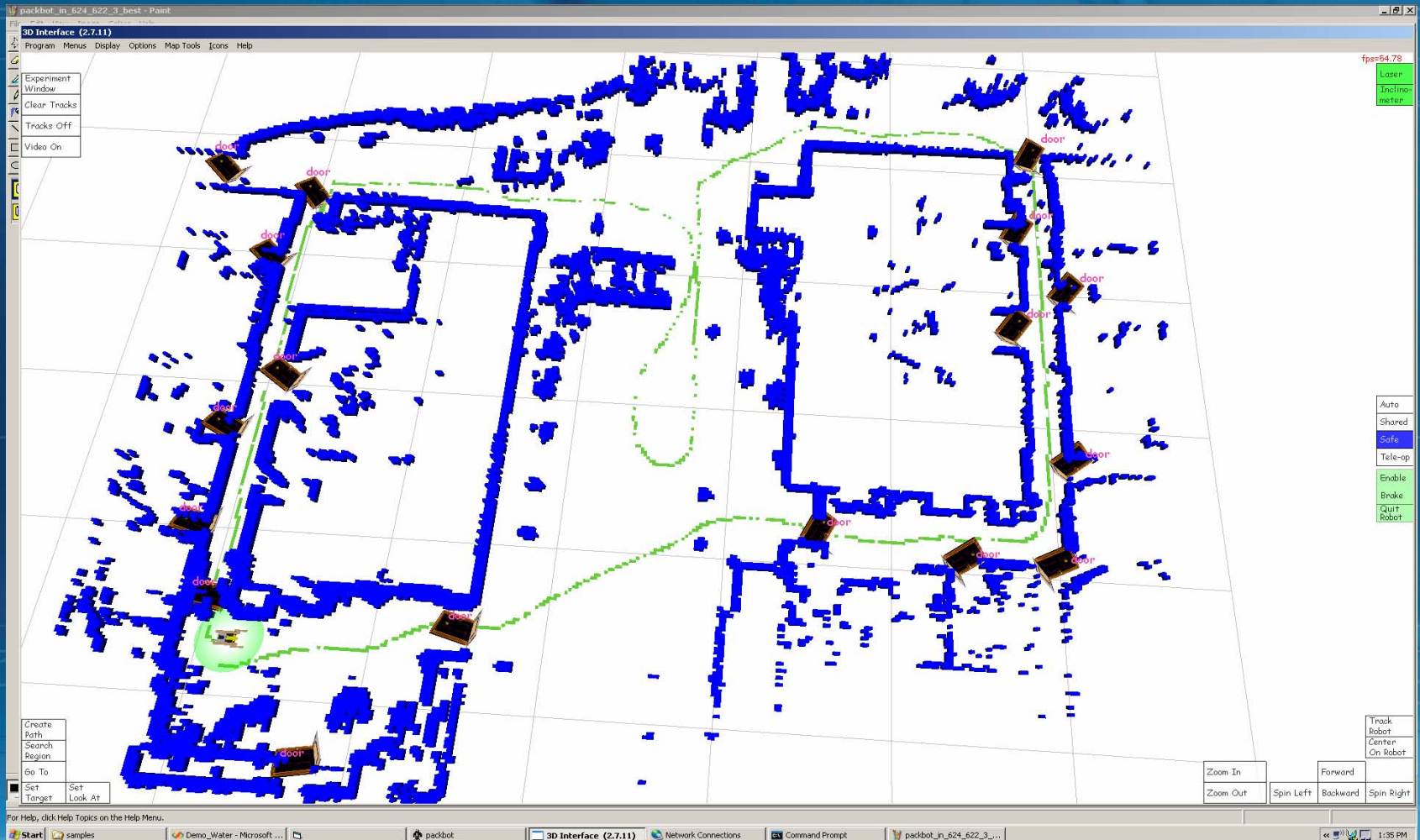
Botdrop

Etc.



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ARMS Capabilities: SLAM (SRI)





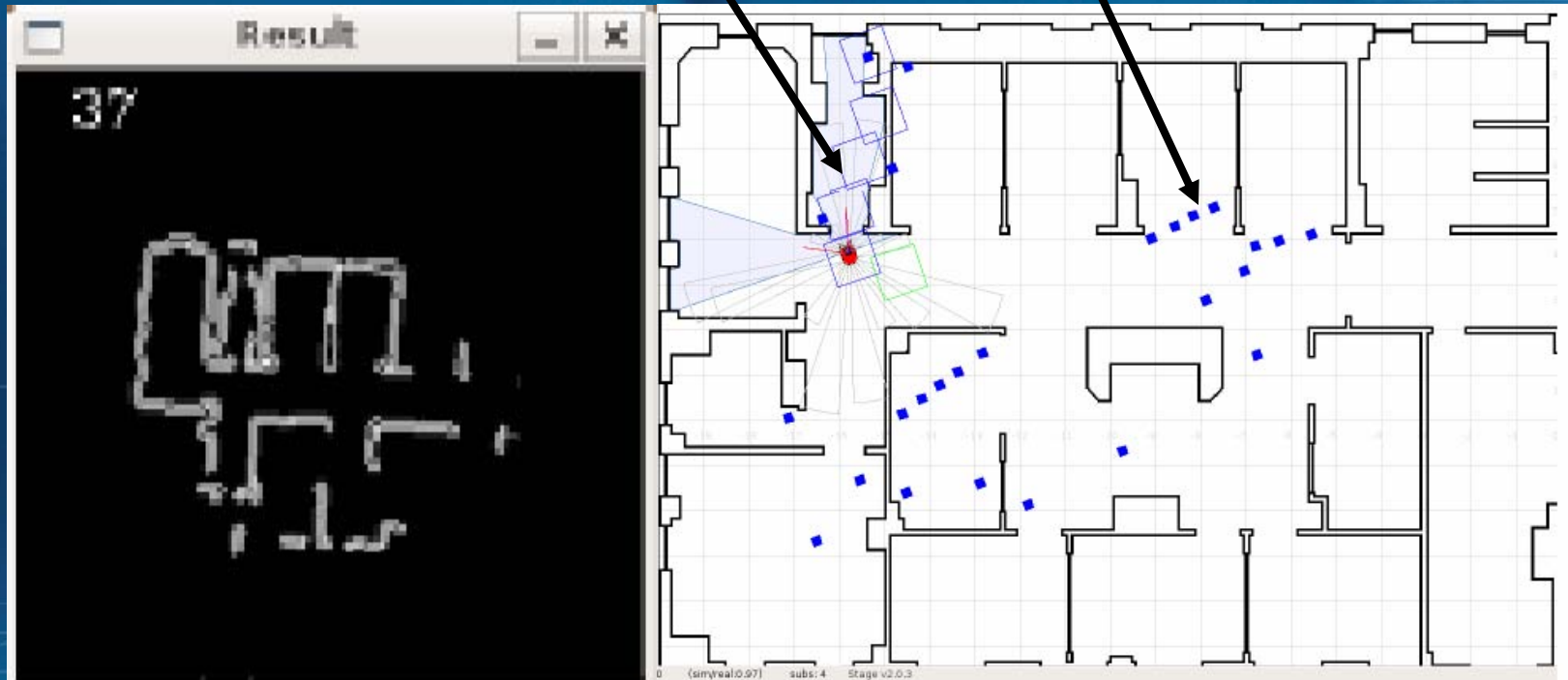
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ARMS Capabilities: Exploration

Current
Map

Waypoints to
Current Goal

Map
"Frontiers"

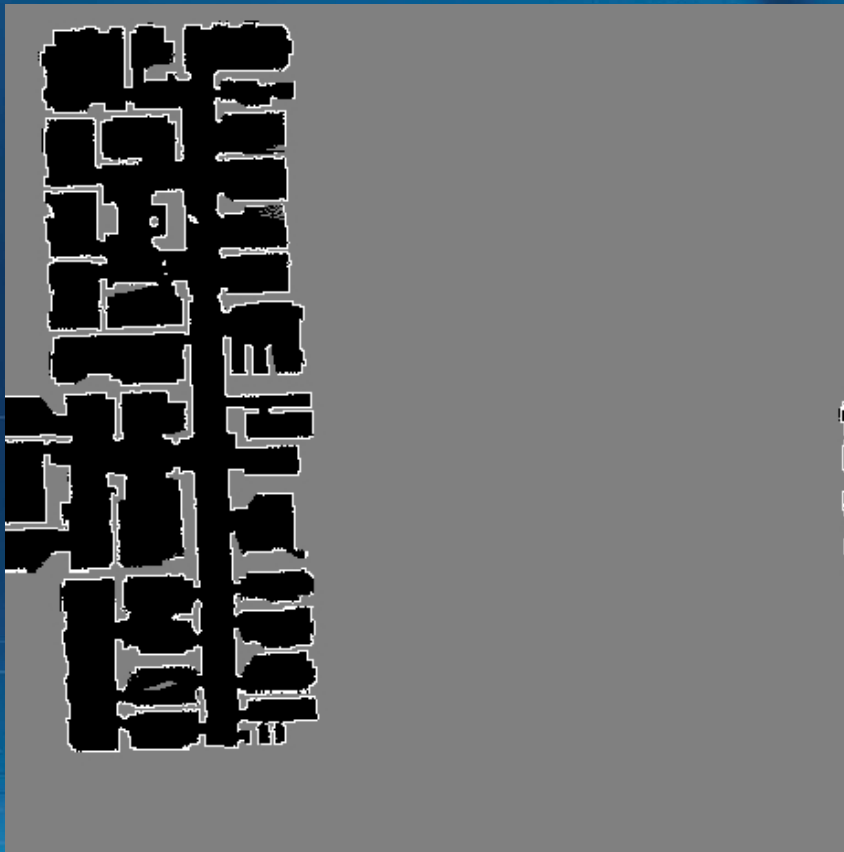




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ARMS Capabilities: Exploration + Room Detection

The Map:



Rooms Perception:

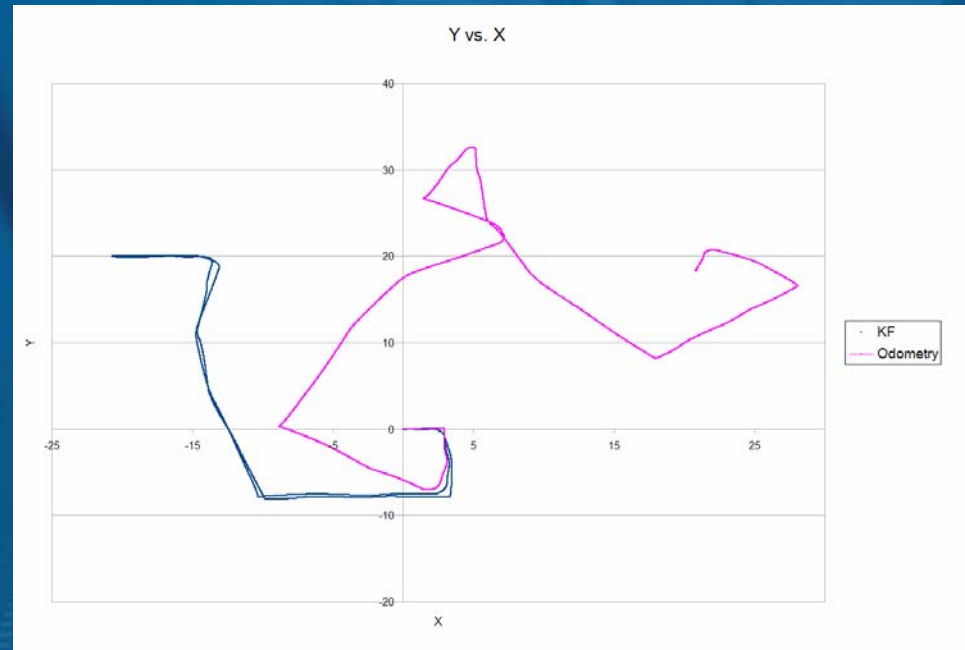




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ARMS Capabilities: Adaptive Extended Kalman Filter

- Adapts to Platform and Sensor Noise
- Fuses GPS, SLAM, IMU, Odometry, Visual Odometry, etc.
- Automatically Chooses Best Sensors.
- Allows for Seamless Indoor-Outdoor Navigation and Geo-Referencing Data



Kalman Filter initial testing on Navigator Payload Packbot.

Date: 12/6/2007

Performed by: Brandon Sights (sights@spawar.navy.mil)

Distance = 118.79 meters.

Error = 0.26 meters.

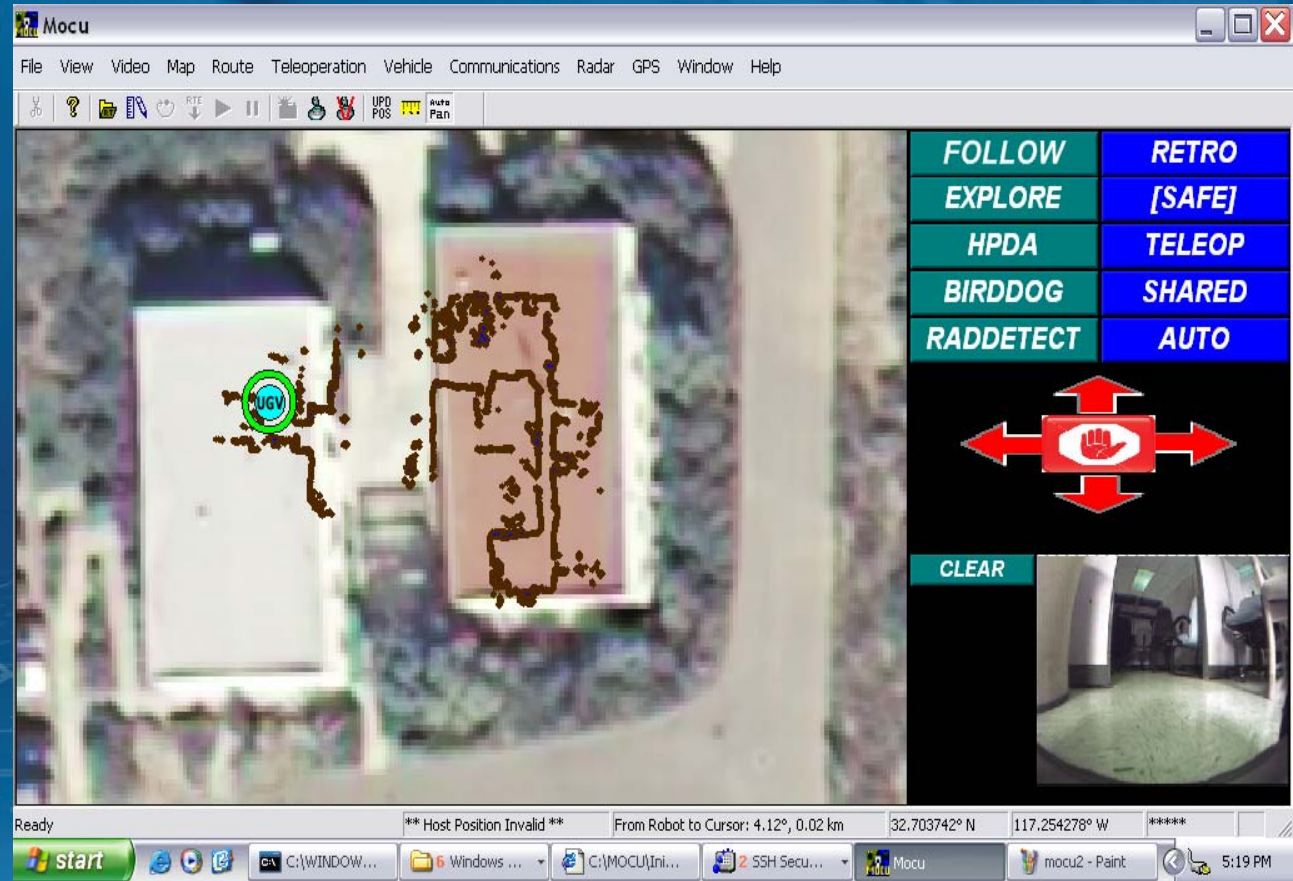
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ARMS Capabilities: Multi-robot Operator Control Unit (MOCU)

- Map and Sensor Data Geo-Referenced
- Geodetic Waypoint Navigation
- Video Feedback
- Easily Choose Task, Influence Behavior, or Teleoperate

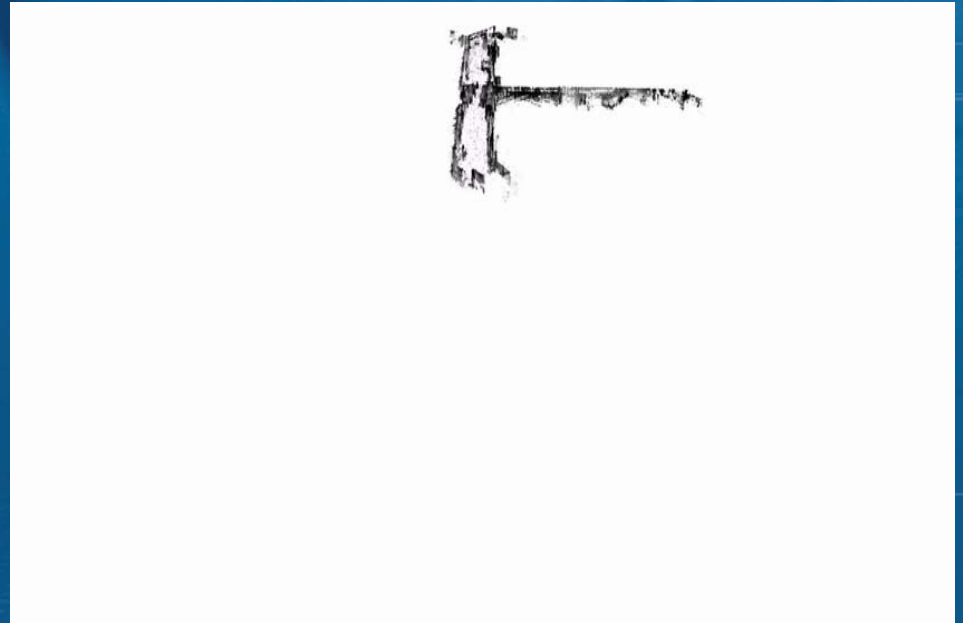




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ARMS Capabilities: Stereo Vision

- Obstacle Avoidance
- 3D Models
- Visual Odometry





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ARMS Capabilities: Target Detection + Following

- Robot Follows Target Using Combination of LADAR, Vision, and/or GPS
- Easier Deployment
- Cooperative Behaviors
- Security

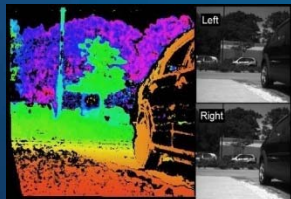




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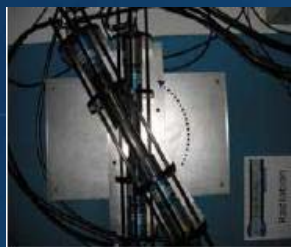
CCAT Projects 2007

- FY07 Solicitation (Smart Robotics Initiative) focused on technologies applicable to man-portable systems
- 6 Awards:



iRobot – Navigator and SEER payloads

[video](#)



SpaceMicro – radiological sensor providing detection and vector to source

[video](#)



SAIC – robot behaviors inferred from operator actions in proximal operations (Warfighter's Associate)

[video](#)

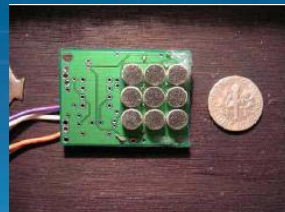


CornerTurn – leave-behind sensors

[video](#)



Digivision – miniature video-contrast enhancement module



AETC – miniature acoustic sensor



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Future Work

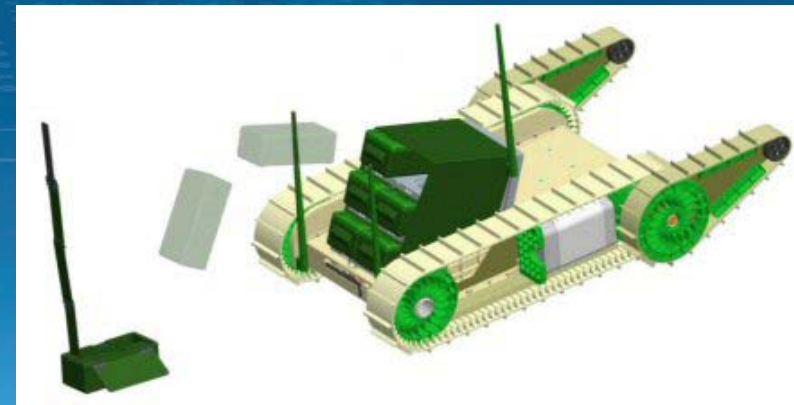
- ARMS Testing
- UrbEE Project
- Tentative CCAT Projects 2008:
 - iRobot Navigator Payload 2
 - SD Technologies Autonomous Gamma Tracking System (AGTS)
 - Think-A-Move Speech Recognition
 - Taser
 - Honeybee Door Breaching Manipulator
- Enhanced Human Robot Interaction



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Automatically Deployed Communication Relays (ADCR)

- Non-line-of-sight communications and increased range
- Ad hoc mesh network based on 802.11 protocol
- Relays automatically deployed when needed
- Self-righting mechanism ensures proper antenna extension
- Only requires an Ethernet interface from the UGV





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Conclusion

- SPAWAR Developing ARMS Based on iRobot Packbot with Navigator and SEER Payloads
- SPAWAR Working With CCAT to Transition Technologies to Man-Portable Robots
- Proven Ability to Rapidly Transition Technologies to Fielded Platforms
- Questions?
 - Contact: **Brandon Sights**
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